NASA TECH BRIEF
Lyndon B. Johnson Space Center

Collapsible Pistons for Light-Gas Guns

The problem:

Hypervelocity light-gas guns have been used to simulate the impact of high-speed meteorites on space vehicle structures. These sophisticated artillery-like devices have been used for launching projectiles to velocities of 9300 m/s (30,000 ft/s), a magnitude greater than that of the ordinary artillery piece. A typical light-gas gun (see Figure 1) is cylindrical in shape and consists of the following: (1) a combustion chamber, (2) a pump tube, (3) a high-pressure section, and (4) a launch tube. One problem with these guns, however, involves the piston in the pump tube. Frequently, these pistons build up pressure either too slowly, resulting in low muzzle velocities, or too rapidly for safe operation.

The solution:

A collapsible piston resolves this problem and increases muzzle velocities up to 14,000 m/s (45,000 ft/s).

How it's done:

The moving and expandable parts of the light-gas gun (Figure 1) consist of a pump-tube diaphragm, a piston, a launch-tube diaphragm, and a saboted projectile. In operation, a gun-powder charge is introduced into the combustion chamber; the chamber is ignited, producing hot high-pressure gases. After reaching a pre-established pressure, these gases burst the pump-tube diaphragm, pushing the piston forward. The piston moves forward at high velocity and compresses a precharged low-molecular gas (generally hydrogen) ahead of it. This gas is compressed rapidly, reaching high temperatures and pressures that are greater than those produced initially in the combustion chamber. Upon reaching the specified pressure, the light molecular gas bursts the launch-tube diaphragm, exposing the sabot behind the projectile. Then both the sabot and projectile are shot out of the muzzle at high velocity toward the target.

The new piston, designed to approximate the ideal pressure cycle for efficiency and high projectile velocity, is shown in Figure 2. Basically, it consists of forward and rear sections and an intermediate collapsible assembly having a male member and a female member. Both the forward and rear sections are made of polyethylene and are conically recessed at the ends. A shear flange on the male member has a slightly larger diameter than the adjacent cavity, which in turn has a slightly larger diameter than the piston section.

As the gun is fired, the new piston races down the pump tube, in the manner mentioned previously, until the compressed gas breaks down the launch-tube diaphragm. At this point, depending on preselected failure strength, the shear flange begins to shear, temporarily

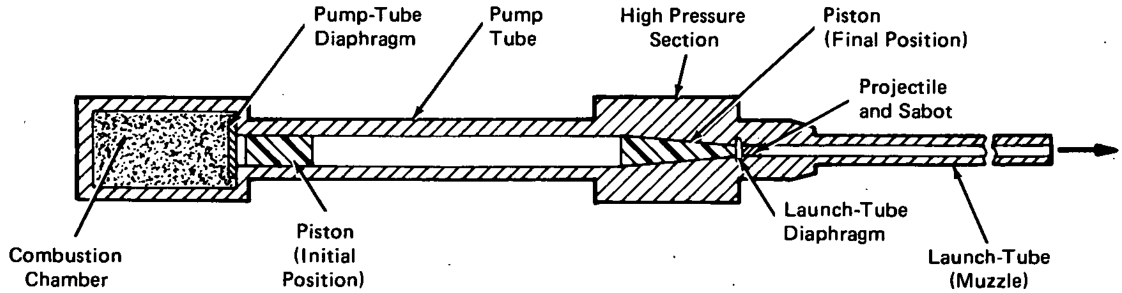

Figure 1. Light-Gas Gun

(continued overleaf)

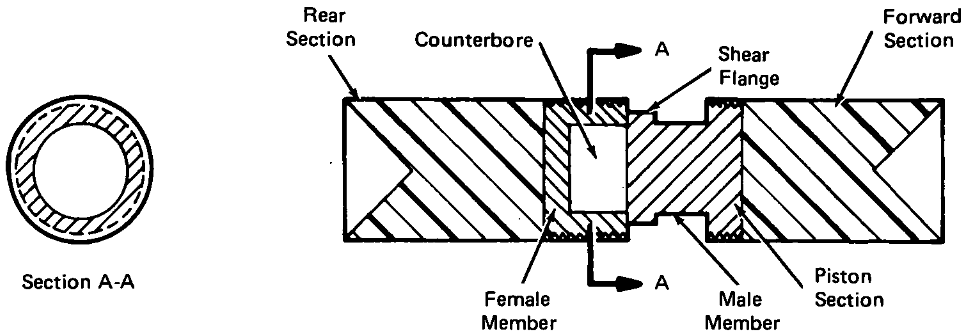

Figure 2. Collapsible Piston

disconnecting the male member from the female member. In effect, the male member becomes axially displaced from the rear member by about 1 cm (1/2 inch). A short time later, the female member catches up with the male member as the piston section engages the counterbore, further compressing the driving gas.

As a result of improved piston design, the pressure cycle has been significantly improved by smoother buildup, increasing muzzle velocities up to 50%.

Notes:

1. Two additional piston configurations have been developed with similar features and are described in a supporting document.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Johnson Space Center
   Code JM7
   Houston, Texas 77058
   Reference: TSP73-10413

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Johnson Space Center
Code AM
Houston, Texas 77058

Source: R. N. Teng of
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